DP IB Environmental Systems & Societies (ESS): SL

Your notes

Conservation of Biodiversity

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Arguments for Preserving Biodiversity

Photo by Alenka Skvarc on Unsplash

The jungles of Costa Rica are among the most biodiverse ecosystems on the planet

- Biodiversity is the range and variety of genes, species and habitats within a particular region
- It is made up of three components:
  - Genetic diversity
  - Species diversity
  - Habitat diversity

- Global biodiversity has a major impact on humans and all other species on the planet
- There are many reasons for maintaining biodiversity, including:
  - Ecological reasons
  - Economic reasons
  - Aesthetic reasons
  - Social reasons
  - Moral/ethical reasons
  - Environmental reasons
  - Agricultural reasons


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Ecological Reasons

- Biodiversity has a major effect on the stability of an ecosystem
  - A more diverse ecosystem is better able to survive and adapt to environmental changes or threats
- For example, if the temperature of a species-rich lake rises due to global warming:
  - Some species of fish in the ecosystem are unable to cope with the change while others can
  - The fish that are able to cope will survive, reproduce and keep contributing to the ecosystem
- Within communities there are keystone species that have a larger impact on the ecosystem than others
  - When these species are lost there are several knock-on effects
  - Bush elephants in the African savannah are a keystone species
    - They graze in a very extreme way, knocking over and eating several species of tree
    - This destruction of vegetation actually helps to maintain the ecosystem
    - Elephant dung also provides a habitat for many important fungi and insect species
    - When elephants were illegally hunted for their ivory, their numbers were reduced and scientists observed a major negative impact on the savannah

Economic Reasons

Photo by Walter Siegmund Wikimedia Commons

The pacific yew tree is a source of anti-cancer drugs

- Ecosystems have a lot of economic value
- Many of the medicines used today have originated from plants, fungi and bacteria
  - For example, the cancer-fighting drug paclitaxel is sourced from Pacific and Himalayan Yew Trees
  - The Himalayan Yew has declined in numbers due to over-harvesting for fuel and medicine
  - Due to the large number of drugs that have already been sourced from nature it is reasonable to assume that there are other drugs, yet to be found in nature, that could be used in the future
- Ecotourism is a major source of income for many countries
  - Many tourists travel to and spend money in National parks so they can see wildlife
  - Increased tourism in a country contributes to the economy and provides jobs

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- Ecosystems have also made major contributions to the field of science and technology
  - The specific enzyme used in DNA sequencing was first discovered in thermophilic bacterium found in a hot spring in Yellowstone National Park, USA


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Aesthetic Reasons

- Humans find great joy and pleasure in the beauty of nature
- It provides inspiration for creatives such as photographers, poets, musicians and artists
- There is a strong argument for preserving biodiversity because of its aesthetic benefits

Social Reasons

- Many people enjoy spending time in the natural environment
- There are many activities that people can do together in nature, e.g. birdwatching, walking, climbing
- Such environments may be lost if they are not conserved, with the loss of the social benefits that they can bring

Many people enjoy spending time in the natural environment bird watching, walking and climbing

Moral & Ethical Reasons

- Many people believe that humans have a moral obligation to prevent the loss of biodiversity that results from human activities
- Humans share the planet with millions of other species and they have no right to cause the extinction of other species
- As humans are the most intelligent species on the planet the responsibility falls upon their shoulders to protect and value all of the organisms on the planet

Environmental Reasons

- Humans need diverse ecosystems because of the essential environmental services they provide
- Plants absorb carbon dioxide from the atmosphere and help to reduce the greenhouse effect and climate change
- Microorganisms digest and break down the masses of organic waste that are produced by larger organisms
- Humans have irrigation and drinking water thanks to the transpiration of plants and their contribution to the water cycle

- Different fungi and bacteria species are a major part of the nutrient cycle that allows for nutrients to reenter the soil for further plant growth
- Plants are producers in food webs. They are both a direct and indirect energy source for humans through fruit, vegetables and meat


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Agricultural Reasons

- Most of the crops that humans grow are very uniform with low genetic diversity
- The wild relatives of crops can provide a source of genetic diversity to rescue crops that are affected by disease or other disasters
- Many of the wild relative species are under threat due to habitat destruction and climate change
- All of the world's potato crop comes from a single species
  - This lack of species diversity makes the crop highly susceptible to disease
  - There are over 100 species of wild potatoes that grow in the Andes
  - These Andean species act as a source of alleles for disease resistance
  - These alleles have been introduced to the potato crop through gene technology and interbreeding

Summary of Reasons for Maintaining Biodiversity

Reason	Explanation
Moral and Ethical	Humans have a responsibility to reduce their impact on the planet and other species
Ecological	Biodiversity increases the stability of ecosystems
Environmental	Organisms provide essential environmental services (water cycle, nutrient cycle and absorption of carbon dioxide)
Economic	A range of organisms contribute to medicine, ecotourism, science and technology
Aesthetic	Humans take pleasure from the visual effects of biodiversity
Agricultural	Genetically diverse wild species can rescue crops from catastrophes

Conservation Organisations & International Conventions

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Conservation Organisations

- Environmental intergovernmental organisations (IGOs) and non-governmental organisations (NGOs) are organisations that focus on promoting environmental protection and conservation efforts around the world

IGOs

- Environmental IGOs are intergovernmental bodies established by states with the aim of promoting environmental protection and conservation efforts on a global scale
- These organisations are usually composed of member states and operate within the framework of international law
- Examples include:

United Nations Environment Programme (UNEP)

- The UNEP is a leading global environmental authority that provides leadership and encourages partnerships in caring for the environment

Intergovernmental Panel on Climate Change (IPCC)

- The IPCC is a scientific body under the United Nations that assesses the science related to climate change, its impacts, and potential future risks

World Conservation Monitoring Centre (WCMC)

- The WCMC provides information services on the conservation and sustainable use of species and ecosystems, and supports others in the development of their own information management systems

NGOs

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- Environmental NGOs are non-profit organisations that are independent of any government and focus on promoting environmental protection and conservation efforts
- These organisations work to raise awareness, lobby governments and businesses, and often carry out practical projects on the ground to protect the environment
- Examples include:

Greenpeace

- Greenpeace is an international environmental organisation that campaigns on various environmental issues such as climate change, deforestation, overfishing, and nuclear power

World Wild Fund for Nature (WWF)

- WWF is an international conservation organisation that aims to conserve nature and reduce the most pressing threats to the diversity of life on Earth

The Nature Conservancy (TNC)

- TNC is a nonprofit environmental organisation that works to protect ecologically important lands and waters for nature and people
- TNC's work spans across 70 countries and all 50 states in the United States

Comparing Environmental IGOs and NGOs

- IGOs and NGOs both play a critical role in conserving and restoring ecosystems and biodiversity
- IGOs such as the United Nations (UN) and its various specialised agencies, such as the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization (FAO), have a global reach and can influence conservation efforts on a large scale
    - NGOs, on the other hand, are often more focused on specific issues and are able to respond quickly to emerging threats to biodiversity

- The effectiveness of IGOs and NGOs in conservation and restoration efforts can vary due to a number of factors, including:
  - Use of media
  - Speed of response
  - Diplomatic constraints
  - Financial resources
  - Political influence
  - Enforceability


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Comparing IGOs and NGOs

Factor	Environmental IGOs	Environmental NGOs
Use of media	IGOs often have a larger traditional media presence (e.g. the news, TV & radio and press releases) due to their size and resources. They can use the media to disseminate information and raise awareness about environmental issues e.g. by reading written statements.	NGOs are often more successful in using media to promote their causes, as they are more nimble and able to respond quickly to emerging issues. They often rely heavily on social and digital media to disseminate information and raise awareness about environmental issues. They may use traditional media less frequently due to limited resources.
Speed of response	IGOs may be slower to respond to environmental issues due to bureaucratic processes and decision-making. However, they often have the resources and capacity to launch large-scale responses once decisions are made.	NGOs can respond quickly to environmental issues due to their flexible structures and ability to mobilise resources quickly. However, their response may be limited in scale and scope.
Diplomatic constraints	IGOs may be constrained by diplomatic considerations, particularly when dealing with issues that involve multiple countries or political sensitivities.	NGOs are generally not constrained by diplomatic considerations and may be more able to take controversial or unpopular positions on environmental issues.

Financial resources	IGOs often have greater financial resources than NGOs due to contributions from member countries and other sources.	NGOs often rely on donations and fundraising for their financial resources, which can be more limited.
Political influence	IGOs may have greater political influence due to the involvement of member countries and their ability to make decisions and set policies at an international level.	NGOs may have less political influence than IGOs, but they can often mobilise public opinion and pressure decision-makers to take action.
Enforceability	IGOs can develop and enforce international laws and agreements, but enforcement can be limited by the willingness of member countries to comply.	NGOs do not have the authority to enforce laws or agreements but can advocate for their implementation and monitor compliance.

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International Conventions

- International conventions on biodiversity work to create collaboration between nations for biodiversity conservation
- Example of these conventions include:
  - The Convention on Biological Diversity (CBD)
  - The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)

The Convention on Biological Diversity (CBD)

- The Convention on Biological Diversity was signed at the Earth Summit in Rio de Janeiro in Brazil in 1992

- The convention had three main goals:
  - The conservation of biological diversity by use of a variety of different conservation methods
  - The sustainable use of biological resources
  - The fair and equitable sharing of benefits arising from genetic resources
- The countries that signed the convention agreed to design and implement national strategies for the conservation and sustainable use of biodiversity, as well as to organise international cooperation and further international meetings

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CITES

- The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) is a global agreement that has been signed by over 150 countries
- Its aim is to control the trade of endangered species and their associated products
  - For example, elephants and their ivory tusks
- CITES categorises endangered and vulnerable species into three appendices:
  - Appendix I: species that are endangered and face the greatest risk of extinction (for example, the red panda)
  - Appendix II: species that are not currently endangered or facing extinction, but will be unless trade is closely controlled (for example, the venus fly trap)
  - Appendix III: species included at the request of the country that is regulating the trade of the species and trying to prevent its overexploitation (for example, the two-toed sloth in Costa Rica)
- There are different trading regulations that apply to each appendix:

- For species in Appendix I: all trade in the species and their associated products is banned
- For species in Appendix II: trade is only granted if an export permit has been issued by the involved countries
- For species in Appendix III: permits are required for regulated trade. Permits are easier to come by for species in this appendix

- Scientists are continuously adding new species and reviewing the status of species already in the database
- There are several concerns about the efficacy of CITES listings:
  - When the trade of a certain endangered species becomes illegal, its price increases
  - The increased economic value of the species can be a major incentive for people to break the law

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Nagoya Protocol on Access and Benefit Sharing

- The full name of this international convention is: The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation
- It is a relatively recent international convention on biodiversity
  - It was adopted at the 10th Conference of Parties to the Convention on Biological Diversity in Nagoya, Japan, in 2010, and entered into force in 2014
- The Nagoya Protocol aims to ensure the fair and equitable sharing of benefits arising from the utilisation of genetic resources, with the goal of promoting the conservation and sustainable use of biodiversity
  - It addresses issues such as access to genetic resources, benefit-sharing, and compliance with national laws and international agreements

Biodiversity Conservation Approaches & Designing Protected Areas


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Conservation Approaches

- Conservation approaches aim to protect biodiversity and ecosystems for the benefit of present and future generations
- These approaches can be broadly categorised into three types:
  - Habitat conservation
  - Species-based conservation
  - Mixed approaches

Habitat Conservation

- Habitat conservation involves the protection and management of ecosystems and habitats
- This approach recognises that the survival of many species is dependent on the preservation of their habitat
  - For example, the Great Barrier Reef Marine Park in Australia uses a habitat conservation approach
  - The park is managed to protect the reef and its inhabitants by controlling the impact of human activity, such as fishing and tourism, and managing water quality

Photo by Bruce Hong on Unsplash

Species-based conservation has been successful in the case of pandas

Species-based Conservation

- Species-based conservation involves the protection and management of individual species
- This approach recognises the importance of individual species to the functioning of ecosystems, or sometimes is used to protect iconic flagship species (species that are globally recognised and that symbolise the importance of biodiversity)
    - For example, the conservation of the giant panda (*Ailuropoda melanoleuca*) in China is an example of species-based conservation
    - The Chinese government has implemented a range of measures, including habitat protection and captive breeding programs, specifically to protect the giant panda, which is an iconic symbol of the country

Mixed Approach to Conservation

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- Mixed approaches involve a combination of habitat and species-based conservation strategies
  - For example, the conservation of the African elephant (*Loxodonta africana*) involves both habitat protection and management of individual elephant populations
  - The African Elephant Action Plan, developed by the African Elephant Specialist Group and endorsed by the Convention on International Trade in Endangered Species (CITES), aims to ensure the survival of African elephants by addressing both habitat conservation and the management of elephant populations
  - The plan involves the protection of key habitats and migration corridors as well as addressing human-elephant conflict, poaching, and illegal trade in elephant ivory
- Most importantly, conservation approaches should be tailored to the specific needs of the ecosystem or species being protected
- A combination of habitat and species-based conservation approaches can be most effective in achieving conservation goals


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Designing Protected Areas

- A protected area is a defined geographical space, such as a national park, wildlife sanctuary, or nature reserve, that is managed and protected for the conservation of its natural resources, biodiversity, and cultural heritage
- Protected areas can be established by national governments, international organisations, or private entities, and are designed to conserve natural and cultural resources for future generations, as well as provide opportunities for scientific research, education, and recreation
- Protected areas can have various levels of protection and management, from nature reserves where human activities are strictly prohibited, to multiple-use areas where certain human activities are permitted (e.g. wild camping)
- Protected areas play a crucial role in conservation efforts, as they provide critical habitat for endangered and threatened species, protect important ecosystems and ecological processes, and provide opportunities for ecotourism and other sustainable economic activities
- Criteria for consideration when designing protected areas include:
  - Size
  - Shape
  - Corridors
  - Edge effects
  - Proximity to potential human influence

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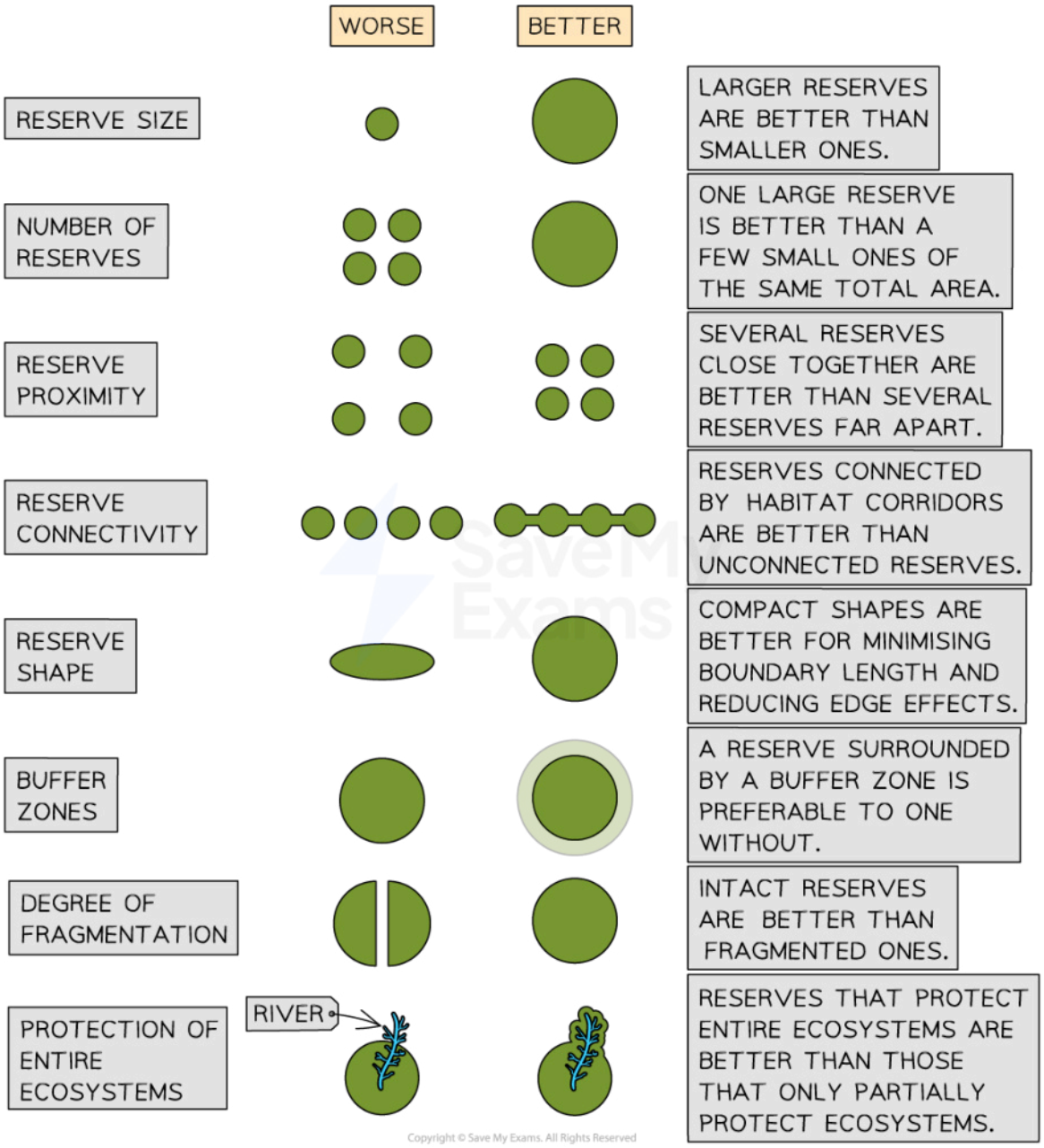

There are many factors to consider when designing protected areas in order to make them more effective for the conservation of habitats and species

Protected Area Design Factors

Criteria for Designing Protected Area	Explanation
Size	The size of a protected area is an important consideration as larger areas can support more biodiversity and provide a greater range of habitats. The size should be large enough to maintain viable populations of target species, allow for natural ecological processes, and minimise edge effects.
Shape	The shape of a protected area can affect its biodiversity by influencing the distribution of habitats and the movement of organisms. A complex shape can increase edge effects, while a simple shape may not provide enough habitat variety. Irregular shapes that follow natural features like rivers and ridges can provide better connectivity and increase the potential for ecological processes.
Edge Effects	Edge effects refer to the changes that occur at the boundary between two different habitats. Protected areas with high edge-to-interior ratios can have negative effects on biodiversity due to increased exposure to human disturbances, invasive species, and altered microclimates. Minimising edge effects can be achieved by creating protected areas with simple shapes or using buffer zones around the edges.
Corridors	Corridors are narrow strips of land that connect otherwise isolated areas of habitat. They can facilitate the movement of organisms and allow for gene flow between populations. Corridors can also provide additional habitat and increase the effective size of a protected area. The effectiveness of corridors depends on their width, length, and the surrounding landscape context.
Proximity to Potential Human Influence	The proximity of a protected area to potential human influence is an important consideration as human activities can have negative impacts on biodiversity. Protected areas that are close to human settlements or infrastructure may be subject to habitat destruction, pollution, and hunting. It is important to balance the need for accessibility and the potential for human impact when designing protected areas.


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Strategies of Biodiversity Conservation


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Species-based Conservation Strategies

- Alternative approaches to the development of protected areas are species-based conservation strategies that include:
  - The Convention on International Trade in Endangered Species (CITES)
  - Captive breeding and reintroduction programmes and zoos
  - Selection of 'charismatic' species to help protect others in an area (flagship species)
  - Selection of keystone species to protect the integrity of a food web

CITES

- CITES is an international agreement that regulates the trade of endangered species and their products
- The goal is to ensure that international trade does not threaten the survival of the species
- It provides a framework for cooperation between countries and sets up a system of permits and regulations to control the trade of endangered species
- CITES has helped to protect many species, including elephants, rhinos, and tigers

Captive breeding, reintroduction programmes and zoos

- Captive breeding is the process of breeding animals in controlled environments, such as zoos, aquariums, or wildlife sanctuaries
- It is often used to help restore populations of endangered species that have declined in the wild
- Reintroduction is the process of releasing captive-bred animals into the wild
- Zoos also play a role in conservation by raising public awareness and funding conservation efforts
  - An example of a successful captive breeding and reintroduction program is the California condor recovery program in the United States

Flagship Species

Photo by Paula Robinson on Unsplash

The mountain gorilla is an example of a flagship species

- Flagship species are charismatic species that are well-known and popular with the public, such as elephants, pandas, or tigers
- They can be used as symbols for conservation efforts and can help to raise awareness and support for conservation efforts
- By protecting charismatic species, their habitats and other species in the same ecosystem may also be protected
    - An example of a flagship species is the mountain gorilla (*Gorilla beringei beringei*)
    - These primates are found in the Virunga Mountains, which span Rwanda, Uganda, and the Democratic Republic of Congo

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- The mountain gorilla population has faced threats from habitat destruction, poaching, and human conflict
- By focusing on the conservation of mountain gorillas and their habitat, conservation organisations have been able to protect not only this species but also the many other plants and animals that share their ecosystem

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Keystone Species

Photo by mana5280 on Unsplash

Sea otters are a keystone species

- Keystone species are species that have a disproportionate effect on the structure and function of their ecosystem.
- Their removal can cause significant changes in the ecosystem, including the loss of other species
- By protecting keystone species, the integrity of the ecosystem can be maintained, which can in turn benefit other species in the ecosystem
    - For example, the sea otter is a keystone species in the kelp forest ecosystem in the Pacific Northwest of the United States, as it helps to control the population of sea urchins, which are herbivores that can damage the kelp forests


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Comparing Conservation Approaches

- The various approaches to protecting biodiversity have different sets of strengths and limitations associated with them
- Community support, adequate funding and proper research influence the success of each of the conservation approaches evaluated below

Comparing Conservation Approaches

Conservation Approach	Strengths	Limitations
Protected Areas	-Provides direct protection to habitats and species -Promotes ecotourism and research opportunities -Can aid in restoration and ecological rehabilitation efforts -May offer ecosystem services to surrounding areas	-Limited land availability -May require displacing indigenous populations -Limited enforcement of regulations -Can be subject to illegal poaching and logging -Can be expensive to manage and maintain
CITES	-Regulates international trade of endangered species -Provides a framework for international cooperation -Protects biodiversity by preventing overexploitation -Supports sustainable use of resources	-Difficult to enforce and monitor trade in remote areas -Can be resource-intensive to implement -Some countries may not prioritise enforcement (or may not have the resources to do so) -Does not address habitat loss or other threats to species
Zoos	-Can serve as a last resort for critically endangered species -Can raise awareness and educate the public	-Limited genetic diversity due to small population size -Animals may experience stress and health issues in captivity

	-Allow for research and educational opportunities -Can provide a safe and controlled environment for breeding	-Some species may not be suitable for captive breeding -Limited capacity for large, wide-ranging species -Can be expensive to maintain and operate
Captive Breeding and Reintroduction programs	-Can increase the population size of endangered species -Can aid in the restoration of ecosystems and food webs -Can increase genetic diversity in populations -Can serve as a way to study species' behaviour	-May not address underlying threats to species -High costs associated with breeding and reintroduction (e.g. transporting species large distances) -Success may depend on habitat availability and quality


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